STUDY PLAN

Aerial/ Ground Application of Methylcyclohexenone (MCH) to Reduce Tree Mortality by Spruce Beetles in South-central Alaska

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I. The Problem

The spruce beetle, Dendroctonus rufipennis (Kirby), is a major killer of spruce across Canada and from the southern Rocky Mountains to Alaska (Safranyik 1985, Schmid and Frye 1977, Werner et al. 1977). During the last 15 years, more than a half a million acres of spruce in Alaska have been infested (Anonymous 1979, 1980, 1981, 1983, 1985, 1987, 1988, 1989). Much of the loss has occurred in areas with high-value trees such as campgrounds, recreational areas, hiking trail systems, and urban areas of small communities. The death of individual trees and entire stands represents large annual losses in forest productivity and wildlife habitat. Beetle-killed timber increases fuel loads within stands which increases the risk of a catastrophic wildfire. Beetle populations have expanded throughout south-central Alaska from 1974 on the Kenai Peninsula including the Chugach National Forest and Kenai National Wildlife Refuge and into the west side of Cook Inlet in the Beluga-Tyonek area and north to Judd Lake.

Many factors contribute to increased spruce beetle activity and potential outbreaks but the most important is the continued stressed conditions under which a tree is growing. Such stressed conditions are caused by 1) lack of silvicultural management which contributes to over-stocked stands that are composed of slow-growing, mature spruce trees; 2) wildfire that places stress on the residual stands in the fringe areas of the fire that were partially burned or damaged by smoke; 3) periodic flooding and deposition of silt on the forest floor, 4) poor utilization of felled trees and accumulation of slash following logging or rights-of-way construction, and 5) windthrown trees.

Past outbreaks in south-central Alaska have been associated with warm, dry summers and an accumulation of spruce debris from windthrown and felled trees which are highly productive breeding sites for spruce beetles. When beetle populations increase and a sufficient supply of breeding material is no longer available for colonization, beetles can infest nearby living trees, particularly in mature stands (Werner et al. 1977).

Endemic levels of spruce beetles can be found in almost any spruce stand in Alaska (Werner and Holsten 1983). The general progression for development of an outbreak would start with the attack of a few "focus" trees in response first to primary host attractants such as monoterpenes or sesquiterpenes and secondly to beetle-produced pheromones. The primary host attractants are usually more concentrated in stressed, slow growing trees (Birch et al. 1980, Hodges et al. 1979, Paine and Stephen 1987, Vite and Pitman 1969, Werner 1972a, 1972b, 1972c, Wood 1972). These trees then act as sites for population increases which are necessary for the beetles to reach epidemic levels. A new brood of adult beetles emerge from the focus trees and attack the adjacent slower growing, less vigorous trees.

Presently, the strategies developed to mitigate the effects of spruce beetles on spruce stands in Alaska involve some form of stand manipulation or the use of chemical insecticides (Werner et al. 1977, Werner 1978). Among the recommended techniques for treatment of logging slash, felled, or windthrown green trees is the immediate salvage of the trees; or disposing by burning, chipping, or burying; or treating with EPA approved insecticides (Werner et al. 1983, 1984, 1986); or use of pheromone-baited traps to reduce Ips engraver

beetle populations (Werner 1989). These techniques are adequate where potential problem areas are accessible.

Recently the use of semiochemicals to manipulate bark beetle populations has gained interest. This includes synthetic attractants, pheromones, antiaggregation pheromones, inhibitors, and repellents or combinations to prevent attack or reduce the attack density of bark beetles to a level below the threshold density required for the development of brood trees. This type of strategy has several advantages. First, ready access to problem areas is not necessary since aerial application of one of the preventive or remedial control techniques might be possible. Secondly, beetle resistance to treatment, with time, would be negligible since successful brood development would be prevented. Lastly, there would be little direct mortality to parasites and predators as occurs with insecticide treatment.

Methylcyclohexenone (MCH) is the primary antiaggregation pheromone used by spruce beetles and is naturally derived from female spruce beetles (Rudinsky 1973). The results of field tests on the efficacy of various formulations and dosages of MCH in Alaska is described in the next section.

II. Literature Review

In 1977, Kinzer et al. (1971) identified methylcyclohexenol (seudenol) as one of the principal aggregation pheromones of the female Douglas-fir beetle, D. pseudotsugae Hopkins. The female beetle releases this pheromone soon after entering a suitable host to which it has been guided by volatile host chemicals (Rudinsky 1966). This pheromone attracts male beetles to the gallery constructed by the female. After the female mates with only one male, she releases MCH which masks the pheromone seudenol and prevents other males from entering the gallery (Rudinsky 1969). Vite and Pitman (1972) isolated seudenol in emergent unmated females Douglas-fir beetles which had fed in the phloem of Douglas-fir trees. Mating disrupted further production of this pheromone.

Seudenol (one of two beetle produced aggregating attractants, the other being frontalin) has also been identified in spruce beetle females (Rudinsky 1973) and could account for the cross attraction between the Douglas-fir beetle and spruce beetle as described by Chapman and Dyer (1969). MCH has been shown to reduce the response of Douglas-fir beetles to an attractive source composed of frontalin, alpha pinene, and host resin (Rudinsky et al. 1972). Research by Furniss et al. (1974) confirmed the density regulation function of MCH. Controlled-release granular formulations containing 2% MCH were developed that eluted MCH in the laboratory at 0.5 ug/h for 60 days (Furniss et al. 1977). An aerial application of a slow-relase granular formulation reduce attacks by the Douglas-fir beetle by 92-97% and reduced brood by 93-99% in felled Douglas-fir logs (Furniss et al. 1981). A granular controlled-release formulation of MCH reduced Douglas-fir beetle infestations in Engelmann spruce by 94.6% and beetle attacks by 55% (McGregor et al. 1984).

Dyer and Taylor (1968) found that one or more female spruce beetles boring in white spruce logs, in the absence of males, created an attraction to both sexes. Even one unmated female in a log attracted more beetles than logs without beetles or with pairs of male and female beetles. The attraction produced by unmated females lasted for three weeks. Dyer and Chapman (1971) concluded that frontalin triggers the process of aggregation of spruce beetles

to white spruce. Attacks were induced on live spruce trees baited with 1 ml of frontalin and on adjacent spruce trees (Dyer 1973).

MCH was identified in 1974 as a major component of the spruce beetle pheromone (Rudinsky et al. 1974). Granular formulation of MCH (3.6% at 10X dosage) reduced attacks of spruce beetle on Sitka spruce by 93% for five weeks. Attacks by by male and female spruce beetles were reduced by 93% when Engelman spruce were baited with MCH in Idaho (Kline et al. 1974). The addition of MCH (300 mg) to sticky traps baited with the natural attractant (female infested bolts) as well as synthetic pheromones (frontalin and alpha pinene) suppressed attacks by spruce beetles in Lutz spruce on the Kenai National Wildlife Refuge by 87 and 99% respectively (Furniss et al. 1976, 1979).

Field studies on the efficacy of slow-release formulations of liquid and granular MCH were undertaken in stands of Lutz spruce in south-central Alaska in 1983 by USDA Forest Service entomologists (Institute of Northern Forestry, Fairbanks and Forest Pest Management, Anchorage). Liquid and granular formulations (98% inert, 2% MCH) were applied around felled trees at three dosages: 4.6, 9.2, and 13.8 kg/ha. The 9.2 kg/ha dosage reduced beetle attacks and beetle brood by 70 and 61% respectively when compared to the untreated controls (Holsten and Werner 1984). Further studies indicated the cool micro-environment of the forest floor and the underside of felled trees was a major factor in preventing complete elution of the MCH from granules formulated to elute at 20°C. In 1984, further field studies were conducted to bracket the dosage rates tested in 1983 (Holsten and Werner 1985). A slow-release granular formulation (98% inert, 2% MCH) was applied at 6.9, 9.2, and 11.5 kg/ha along the top side of felled Lutz spruce using a hand-held fertilizer spreader. The elution rate was 0.38, 0.50, and 0.63 g of MCH/ha/day; effective for a 30-60 day period. The elution rates were determined in the laboratory at 21°C at 50% relative humidity for 32 days. Elution rates were also determined in the field. The results showed no significant differences ($P < 0.05$) bewteen treated and untreated controls. This lack of efficacy was contributed to the lower than expected release rate of the MCH formulation. The laboratory tests showed an average loss of 3.7 g MCH/ha/day which falls within the optimal rate (0.5-5.0 g/ha/day) determined in the 1983 study (Holsten and Werner 1984). The variation, however, around this mean was $\pm$ 5.3 g/ha/day, which demonstrated that the elution rate was not constant. The field elution rate was 1.81 g/ha/day for 32 days; 51% less than the laboratory elution rate. Again, the conclusion was that the cold micro-environment of the forest floor retarded elution of MCH (Holsten and Werner 1986). During the 1984 field tests, there was a 29% increase in attack density of untreated check trees over beetle density in 1983 which indicates the release of natural aggregating pheromones could have "overwhelmed" the antiaggregation effects of MCH. Field tests for protecting individual trees using MCH-impregnated bubble caps was also tested in south-central Alaska (Holsten and Werner 1987).

III. Objective

The objective of this field experiment is the test the efficacy of aerially or ground applied methylcyclohexenone (MCH) to prevent the infestation of tree-length log decks by spruce beetles.

IV. Methods

Characteristics of MCH

MCH will be formulated into a controlled release bead consisting, by weight, of an inert polyethylene bead (98%) charged with 2% MCH. This controlled release formulation has significantly reduced Douglas-fir and spruce beetle attacks in Idaho when applied at a dosage rate of 4.6 kg/ha. This amount of formulated bead elutes from 0.25 to 2.5 g MCH/ha/day for 60 days (Furniss et al. 1981). Previous studies in Alaska (Holsten and Werner 1985) have shown that field elution rates of the formulated plastic bead in a cool environment were 50% of the rates reported elsewhere; therefore, two dosage rates will be tested in this study: 4.6 and 9.2 kg/ha.

Study Areas

The Enstar Gas Company has constructed a 16-mile-long gas line righ-of-way between Tyonek and Beluga on the west side of Cook Inlet. The trees originally in this right-of-way were felled in the fall of 1990 and are decked along both sides of the right-of-way. The areas adjacent to the right-of-way are largely composed of mature Lutz spruce with some mixed stands of spruce and paper birch. These stands are interspersed with bog areas of black spruce and blue-joint grass. The log decks to be treated are scattered along the entire length of the right-of-way. Populations of spruce beetles in this area are currently endemic.

Experimental Design

The experiment will consist of three treatments:

1. MCH at 4.6 kg/ha
2. MCH at 9.2 kg/ha
3. Untreated control

Each MCH treatment will be replicated 7 times; the controls 7 times on 500 x 110 feet requiring 21 individual 1.26 acre plots with a minimum distance of 500 feet between plots. A complete randomized block design will utilize 7 blocks of each of the 3 treatments per block. Treatments will be randomly assigned to the 7 blocks. Block locations will be selected so that Lutz spruce comprises at least 50% of the log decks. Phero Tech Inc. will formulate the plastic beads with the various treatments in Delta, BC and send to Anchorage at least 10 days before application. Phero Tech will also provide specific information for each formulation relative to optical and technical composition and purity.

The beads will be applied by helicopter and/or motorized ground applicator. The helicopter equiped with an aerial seeder (hopper) will be calibrated to deliver the correct application rates using blank beads prior to application.

Evaluation

A multi-stage subsampling scheme for estimating the total number of adult attacks and subsequent brood density will be used. First, the number of spruce logs, and logs of other tree species, in 20% of the decks will be counted to estimate the proportion of spruce in the decks. Only log decks with similar percentages of spruce will be treated. Fifteen to 20% of the spruce logs in

the selected decks (minimum of 15 logs) will be examined for the presence of spruce beetle attacks. The 15-log subsample per block will be further divided into 3 vertically stratified log subsamples with one log on top, one in the middle, and one on the bottom of the deck. The 3-log subsamples will be randomly distributed throughout each of the 21 blocks. Two pairs of 6x6" (or circular???) bark samples will be removed from each sample log; one pair from each of the lower and mid-log sections. From each bark sample, the number of egg gallery starts and number and stage of brood will be counted. The members of each pair of samples will be taken from mid-line on opposite sides of the log.

V. Statistical Analysis

Data will be tested for homogeneity. If non-homogenous, data transformations will using arc sine. The arc sine square root of the proportion of trees in each treatment will be calculated to equalize the variances. A one-way analysis of variance will be performed using Tukey's multiple range test to identify subgroups that are significantly different at the 0.05 probability level.

VI. Time Schedules

	List of Jobs	Completion Date
1	Reconnaissance flight	November 1990
2	Meeting with Kenai Borough Officials	January 1991
3	Meeting with Tyonek and State Officials	January 1991
4	Preparation of study plan	February 1991
5	Plot establishement	May 13-15, 1991
6	Treatment	May 16-17, 1991
7	Treatment evaluation	August 1991
8	Data Analysis	Oct-Dec 1991
5	Study report	December 1991

VII. Personnel Assigned

Name	Position	Location	Days	Cost
Richard A. Werner	Research Entomologist	Fairbanks	20	$6,500
Pat Shea	Research Entomologist	Berkeley	10	3,000
Edward H. Holsten	Entomologist	Anchorage	20	5,000
Danny Lyon	Biological Technician	Anchorage	20	3,500
Robert Wolfe	Biological Technician	Anchorage	10	2,000
Ken Zogas	Biological Technician	Anchorage	10	2,000
Eugene Culp	Maintenance Mechanic	Fairbanks	5	1,000
Seasonal	Forestry Technician	Anchorage	20	3,000

VIII. Estimated Costs

Salaries	$26,000
SUBTOTAL	26,000
Transportation	
Air - Fairbanks to Anchorage ($140/person RT x 5 trips)	700
San Francisco to Anchorage ($700/person RT x 3 trips)	2,100
Subsistence ($10/day/person x 10 days=$100/day)	1,000
Per diem ($120/day/person x 16 days)	2,000
Transportation of hopper	600
Helicopter charter	6,000
Helicopter foreman	1,000
SUBTOTAL	13,400
Equipment and Supplies	
Gas powered saw with disc-cutting blade	600
Spray Paint	50
Stakes (1/2 inch x 5-foot rebar)	100
Grass seed spreaders, hand operated, 3	100
Flagging	50
Plywwod signs and plot markers	200
MCH beads, loaded and unloaded	2,878
Computer time	2,000
SUBTOTAL	5,878
TOTAL	$45,278

IX. Expected Accomplishments

Successful completion of this experiment should provide important data on the ability of MCH to manipulate populations of spruce beetle. These data will allow us to design guidelines for the use of MCH by certified PCO's once MCH becomes registered.

X. Application of Research Results

Data will be compiled and analyzed following completion of the 1991 field season. A report will be prepared in December 1991 and provided to Enstar and the land owners along the right-of-way corridor. Results will also be published in a scientific journal.

XI. Health and Safety

Forest Service personnel will be conducting most of the work listed in this study. This study requires close awareness and enforcement of safety regulations because of the hazards involved in field work and riverboat travel in interior Alaska.

All events scheduled in this study will be done in compliance with the Forest Service Health and Safety Code Handbook (FSH 6709.11). A Job Safety and Health Hazard Analysis (FSM 6740) will be made prior to the start of the study. All employees involved in the study will be trained and instructed in the basic

safety and health precautions to be followed. All supervisors should have a valid first-aid card and be trained in CPR.

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